MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2022/2023

ERT3026–AUTOMATION

(RE)

05 OCTOBER 2023
9.00 a.m. - 11.00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 7 pages excluding the cover page with 4 Questions only.

2. Attempt **ALL** the questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

a.

A certain part is routed through 6 machines in a batch production plant. The setup time and operation time for each operation or machine are given in **Table Q1(a)**. The batch size is 100 and the average non-operation time per machine is 12 hrs.

i. Determine manufacturing lead time [9 Marks]

ii. Determine production rate for operation 3 (machine 3). [3 Marks]

Suppose that the part is made in very large quantities on a production line in which an automated work handling system is used to transfer parts between machines. Transfer time between workstations is 15 s. The total time required to set up the entire line is 150 hrs. Assume that the operation times at the individual machines remain the same.

iii. Determine manufacturing lead time for a part after the production has achieved steady state operation. [3 Marks]

iv. Determine production rate for operation 3. [3 Marks]

v. Theoretical production rate for the entire production line. [2 Marks]

Table Q1(a)

Machine	Setup time (hr)	Operation Time(min.)
1	4	5.0
2	2	3.5
3	8	10.0
4	3	1.9
5	3	4.1
6	4	2.5

Continued ...

b.

If the revenue is RM 60,000 per year and the cost is RM 30,500 per year. Capital costs IC = RM 100,000. The life span of the equipment is 12 years. Consider the annual interest of 20%. Determine the equivalent Uniform Annual Cost (UAC) for the project. [5 Marks]

Question 2

a.

In the Industrial application, there is a machine with a large steel shaft supported by babbitted bearings. This shaft is a coupled to a large electric motor. The bearings need lubrication, which is supplied by an oil pump driven by a small electric motor. The operation of the program can be summarized as follows:

- To start the machine, the operator turns **SW** on.
- Before the motor shaft starts to turn, the bearings are supplied with oil by the pump for **10 seconds**.
- The bearings also received oil when the machine is running.
- When the operator turns SW off to stop the machine, the oil pump continues to supply oil for **15 seconds**.
- A retentive timer is used to track the total running time of the pump. When the total running time is **3 hours**, the motor is shut down and a pilot light is turned on to indicate that the filter and oil need to be changed.
- A **reset button** is provided to reset the process after the filter and oil have been changed.

Draw the PLC ladder logic diagram for the above scenario. [15 Marks]

b.

Write a programmable logic controller (PLC) ladder diagram to control forward and reverse running of the motor as shown in **Figure Q2(b).** This is possible by using two switches forward switch (X0) and reverse switch (X1) and the operating conditions are summarized as follows:

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- The forward switch is pressed,
- After **1 second**, contactor Y0 will be enable and the motor run forward.
- The reverse switch is pressed,
- After **2 seconds**, contactor Y1 will be enable and the motor run reverse.
- Y0 and Y1 will be disabling and the motor will stop running.

Draw the PLC ladder logic diagram for the above scenario. [10 Marks]

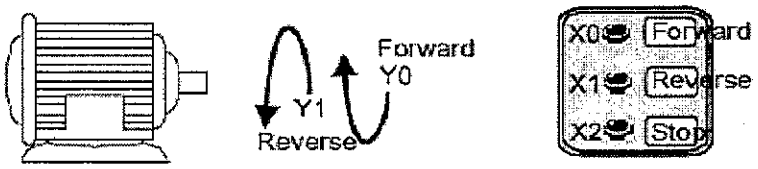

Figure Q2(b): Motor for Question 2(b)

Question 3

a.
An eight-station rotary indexing machine operates with an ideal cycle time of 40s. The frequency of line stop occurrences is 0.2 stop / cycle on the average. When a stop occurs, it takes an average of 2.0 minutes to make repairs. Determine:

i. Average production rate *Rp*. [4 Marks]

ii. Line efficiency *E*. [3 Marks]

iii. Proportion of downtime *D*. [3 Marks]

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b.

An eight-station rotary indexing machine performs the machining operations as shown in the **Table Q3(b)**.

The transfer time for the machine is 0.15 min per cycle. A study of the system was undertaken, during which time 1000 parts were completed. It was determined in this study that when breakdown occur, it takes an average of 5 min to make repairs and get the system operating again. For the study period, determine:

i. Average actual production rate [10 marks]

ii. Line uptime efficiency [2 marks]

iii. The time required to produce the 1000 parts [3 marks]

Table Q3(b): Processing time and Breakdowns for Each Process

Station	Process	Process time	Breakdowns
1	Load part	0.50 min	1
2	Mill top	0.85 min	47
3	Mill sides	1.26 min	88
4	Drill two holes	0.60 min	8
5	Ream two holes	0.43 min	31
6	Drill six holes	0.92 min	58
7	Tap six holes	0.75 min	22
8	Unload part	0.40 min	1

Question 4

a.

A flexible manufacturing system (FMS) is used to produce four parts. The FMS consists of one load/unload station and two automated processing stations (processes X and Y). The FMS also includes an automated conveyor system with individual carts to transport parts between servers. The carts move the parts from one server to the next, drop them off, and proceed to the next delivery task. The average time required per transfer is 3.5 minutes. The details of FMS can be summarized as shown in **Table Q4.1**

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Table Q4.1

Station 1	Load and unload	Number of human servers (workers) to be determined
Station 2	Process X	Number of automated servers to be determined
Station 3	Process Y	Number of automated servers to be determined
Station 4	Transport system	Number of carts to be determined

All parts follow the same routing, which is **1 → 2 → 3 → 1**. The product mix and processing times at each station are presented in the **Table Q4.2**:

Table Q4.2

Product j	Product mix p_j	Station 1	Station 2	Station 3	Station 1
A	0.1	3 min	15 min	25 min	2 min
B	0.3	3 min	40 min	20 min	2 min
C	0.4	3 min	20 min	10 min	2 min
D	0.2	3 min	30 min	5 min	2 min

Required production is 10 parts per hour, distributed according to the product mix indicated in **Table Q4.2.** Use the bottleneck model to determine:

i. The average workload for each station and the transport system. [10 Marks]

ii. The minimum number of servers at each station and the minimum number of carts in the transport system those are required to satisfy production demand. [10 Marks]

b.

Explain the distinguishing characteristics of the three categories of flexible manufacturing cells and systems graphically. [5 Marks]

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APPENDIX

TABLE 1: Useful Formulas

$R_p = \frac{1}{T_p}$	$T_p = \frac{T_b}{Q}$	$T_b = T_{su} + QT_c$	$T_c = \text{Max}\{T_m, T_s\} + T_r$	
$E = \frac{T_c}{T_p}$	$T_c \leq \frac{E}{R_p}$	$T_p = T_c + \sum_j F_j T_d$	$C_{pc} = C_L T_p + C_m + C_t$	
$D = \frac{FT_d}{T_p}$	$R_{dv} = \frac{AT}{T_c}$	$d = \frac{nT_s - T_{wc}}{nT_s}$	$T_C = T_L + \frac{L_d}{v_c} + T_U + \frac{L_e}{v_e}$	
$T_t = \frac{L_s}{v_c}$	$E_b = \frac{T_{wc}}{n\,T_s}$	$AT = S_w H_{sh} AU$	$WL = \frac{QT_c}{(1-q)E_w}$	
$T_c = \frac{s_p}{v_c}$	$f_p = \frac{v_c}{s_p}$	$AT = 60\ A\ T_f\ E$	$WL_{n+1} = n_t t_{n+1}$	
$s_c = v_c\ T_L$	$v_c = \frac{L_d}{T_d}$	$AT = H_p\ A\ U$	$T_{wc} = \sum_{j=1}^{n_e} T_{ej} = \sum_i^n T_{si}$	
$n = \frac{R_f}{R_{dv}}$	$n = \frac{WL}{AT}$	$WL = R_f\ T_c$	$WL_i = \sum_j \sum_k t_{ijk}\ f_{ijk}\ p_j$	
$ET = \frac{L}{v_c}$	$n = \frac{w}{M}$	$R_p^* = \frac{s^*}{WL^*}$	$n_t = \left(\sum_i \sum_j \sum_k f_{ijk}\ p_j\right) - 1$	
$F = \sum_i^n p_i$	$L = \sum_{i=1}^n L_{si}$	$F = 1 - \left[\prod_{i=1}^n (1 - p_i)\right]$	$N^* = R_p^* \left(\sum_{i=1}^n WL_i + WL_{n+1}\right)$	
$R_p^* = \frac{s^*}{WL^*}$	$U_i = \frac{WL_i}{s_i}(R_p^*)$	$\overline{U} = \frac{\sum_{i=1}^{n+1} U_i}{n+1}$	$\overline{U_s} = \frac{\sum_{i=1}^n s_i U_i}{\sum_{i=1}^n s_i}$	
$ET = n\ T_t$	$R_{pj}^* = p_j(R_p^*)$	$BS_i = WL_i(R_p^*)$	$FOHR = \frac{FOHC}{DLC}$	$COHR = \frac{COHC}{DLC}$
$CRF = \frac{i(1+i)^n}{(1+i)^n - 1} = \frac{A}{P}, i\%, N)$				

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TABLE-2 Extended Bottleneck Model

Case 1: N < N*	Case 2: N ≥N*
$MLT_1 = \sum_{i=1}^{n} WL_i + WL_{n+1}$	$R_p^* = \frac{s^*}{WL^*}$
$R_p = \frac{N}{MLT_1}$	$R_{pj}^* = p_j(R_p^*)$
$R_{pj} = p_j R_p$	$MLT_2 = \frac{N}{R_p^*}$
$T_w = 0$	$T_w = MLT_2 - \sum_{i=1}^{n} WL_i + WL_{n+1}$

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